United States Department of Agriculture
Office of Pest Management Policy
Washington, D.C. 20250

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Note to TRAC Members:

Enclosed is a copy of the recently-completed report on the technical foundation for a transition strategy for apple production in the Mid-Atlantic/Appalachian/Southeastern region. To produce this report, USDA assembled a workgroup of apple growers and technical experts from that area. By taking a pest-by-pest approach, this group identified pest management practices and needs. Their analysis is presented in this report. The report also recommends next steps for USDA, EPA, and others to ensure a workable transition.

Similar reports are being prepared or are planned for other commodities including California peaches, Southeastern peaches, almonds, and Northwest pome fruits. Reports are being produced cooperatively by USDA, Land Grant Universities, producers, and production experts.

USDA is seeking feedback on this first report which will be part of the discussion on Transition Issues during the October 20 session of the upcoming TRAC meeting.

> Does the report establish the needed direction, tone, context for transition?
>
> What are your suggestions for improving such reports? For improving the process to produce reports?
>
> What next steps are needed when reports are completed? What process or processes are needed to begin prioritization and implementation of the recommendations?

We look forward to discussing transition issues and this report with you at the TRAC meeting next week.

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The Foundation for a Transition Strategy for Lessening Dependency on Organophosphate Insecticides in the Mid-Atlantic/Appalachian/Southeastern Apple Production Region

Workshop held June 10-11, 1999
Washington DC
October 25, 1999 Edition

WORKGROUP PARTICIPANTS

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BACKGROUND:

Apple production is a major agricultural business in the Mid-Atlantic/Appalachian/ Southeast region of the United States. Apples are grown on 69,000 acres in these eleven states (DE, GA, MD, NC, KY, OH, PA, SC, TN, VA, WV) and account for $120 million in agricultural income annually. Apple production in this region accounts for 10% - 14% of the total U.S. annual production, 60-75% of which is sold for processing.

Numerous insect and mite species occur in and around apple orchards in this eleven state region. Some are sporadic pests while others need to be managed every year to prevent damage to the apple crop. Apple pests may feed directly on the fruit, on the leaves, or on the trunks or roots. Apples that are damaged directly by insect feeding are not acceptable on the fresh market, while tree and leaf feeding can result in fewer and smaller apples, poor color development, as well as weakened trees. Apples with internal worms and/or damage are not acceptable in the processing market. Essentially, 100% of the apple acreage in this region is treated with insecticides/miticides to manage insect and mite pests.

Organophosphates (OPs) are the most widely used class of insecticides in apple orchards in this eleven state area. The OPs are broad spectrum in that they control many of the key insect pests that appear every year and some of the sporadic pests and other formerly injurious species that seldom appear today. Frequently a single application is used to control two or more key pests simultaneously. The organophosphates are economical; pest resistance to the OPs is not wide spread; and they do not harm key beneficial species that are a part of current IPM programs. These tools are at risk of being lost.

EPA is in the process of re-registering pesticides under the requirements of the Food Quality Protection Act (FQPA). The Agency is examining dietary, ecological, residential, and occupational risks posed by the organophosphates. EPA's regulatory focus on the organophosphate insecticides has created uncertainty as to their future availability for apple growers. At some point the EPA may propose to modify or cancel some or all uses of organophosphates for apples. The regulatory studies that EPA requires registrants to complete may result in some companies voluntarily canceling organophosphate registrations for apples. The continued focus on risks of organophosphates may lead some apple processors and packinghouses to require that growers not use the organophosphates. At this point no one can predict which of the organophosphates will be available for apple growers in the future.

Recent activities at the USEPA clearly indicate that the regulatory process aims to reduce or eliminate the use of certain "high risk" pesticides (organophosphates, carbamates, and B2 carcinogens) especially when used on foods consumed by infants and children. In addition, environmental groups are raising public awareness through campaigns addressing pesticide use and residues, especially on apples, peaches, and pears. Public awareness can lead to consumer pressure on food processors and packers to sell produce that is free of pesticide residue.

Clearly OP risks and concerns are not going to go away. Agriculture needs to respond in a proactive manner. We can bury our heads in the sand, ignore the writing on the wall, allow the EPA and the environmental groups to tell us what we are going to do, or we can be proactive, develop transition strategies that reflect the needs of growers, and show the EPA and others what agriculture can do to reduce and eliminate OP use, risks, and residues.

The USDA, the EPA, the land-grant universities and the apple industry (growers and processors) need to pro-actively identify regulatory, research, and educational needs for replacing the OPs with effective alternatives, if necessary, as a result of EPA's regulatory actions during the implementation of the FQPA. This is the goal of the "Foundation for a Transition Strategy" document.

The Work Group

A workgroup consisting of apple growers and technical experts (entomologists, IPM specialists, private consultants, and researchers) met June 10-11 in Washington, D.C. The goal of the group was to develop a foundation for a transition strategy for apple growers in the Mid-Atlantic/Southern/Appalachian region that could lessen or possibly eliminate OP use in apple production. The effort and outcome of this group reflects the Vice President's call for a "reasonable transition for agriculture" as outlined in his April 8, 1998 memo to the EPA and USDA regarding implementation of the FQPA.

Several key principles were kept in mind as the group proceeded:

1. First and foremost was the welfare of the farmer; any transition proposal developed had to allow for the continued profitability for apple growers by providing cost-effective alternative pest management tools.
2. Geographical regions had to be considered when developing transition strategies due to differences in production practices, pest complex and pressure, environmental conditions, crop varieties, and marketing opportunities.
3. The big picture needed to be considered. A one chemical at a time process would not work. The workgroup believed that discussing the issues in terms of chemical class (OPs), individual commodity (apple), and specific pests would be the most effective way to develop a transition strategy.
4. The group would identify gaps and needs that would become the basis for the "TO DO" list. This "TO DO" list identifies what is needed in terms of research, regulatory actions, and educational programs as the apple growers in this specific region move away from OP use.

General conclusions of the workgroup:

- anyone still in the business of profitably growing apples has adopted IPM principles
    - IPM practices include monitoring (including use of mechanical and pheromone based traps), scouting, cultural practices (e.g., orchard floor management), reducing application numbers and rates, appropriate timing of applications, preserving beneficials, etc.
- for some key pests of apple orchards in this region there are no currently available effective alternatives to the OPs
    - an accelerated and adequately funded research and regulatory program may produce

effective alternatives

- if OPs were not available for use during petal fall, esfenvalerate would be used by default and mites, scale insects, aphids and "For Sale Signs" would dominate the orchards
- for some key pests of apple orchards in this region effective non-op alternatives do currently exist
  - some of these alternatives are toxic to beneficial mite and insect predators, and, as a result, insecticide/miticide use would increase
- pest selective alternatives exist for some insect pests
  - due to their selective activity against key pests these alternatives for the broad-spectrum organophosphates may result in the emergence of secondary pests and the need for additional insecticide applications
- if OPs were removed from the system, there would be increased reliance on only a few selective insecticides/miticides, which could result in widespread pest resistance within a short period of time
- potential alternatives (pipeline chemistries) are unproven in this region due to a lack of complete testing - effects from their use are difficult to predict
- registration of certain experimental insecticides may provide effective replacements for certain OP uses in this region
- more research is needed to screen and evaluate experimental compounds and IPM practices
- the use of chemical alternatives to the organophosphates will significantly increase costs for growers
- there are not enough researchers available to do all the research that is needed
- extension/education/training programs are needed once new management tools are identified and/or registered to teach growers how to use them and what to expect
- effort and/or funding sources for needed research programs could come from:
  USDA
  Land-grants
  Private researchers
  Food processors
  Commodity groups
  Grower associations
  Environmental groups
  Registrants
  Retailers
  States
  EPA

GENERAL "TO DO" LIST:

- the need for breeding programs to discover and develop insect and mite resistant varieties
- research on beneficial insects and mites; especially evaluation of pesticide toxicity to the beneficials
- there is a need to increase the research effort in all aspects of pest/pesticide management
- 4-6 year research programs need to be funded; currently 1-2 year funding is common, but this is not sufficient time to do orchard type research

- need for large plot (10-30 acres) long term research projects – a systems approach to research
- need changes to the Experimental Use Permit (EUP) process at EPA – possible insurance programs for EUP research; non-crop destruct permits
- funding needed for non-chemical pest management research strategies: (e.g., biocontrol programs, mating disruption, cultural practices including ground cover management, etc.)
- expand area-wide research programs
- pesticide residue management research is needed

FOUNDATION FOR TRANSITION:
The remainder of this document is a pest by pest discussion regarding the role of organophosphates, the use of alternatives (chemical and non-chemical), and the potential of the pipeline pest management tools. Pests are discussed in order of appearance during the growing season following apple tree phenology (pre-bloom, petal fall, post-bloom through harvest). Growers may need to make more than one application during any one of the timing intervals. The "cover sprays" may need to be extended to eight or may be discontinued after four depending on pest monitoring observations. Miticide applications (which don't include the organophosphates) are made when necessary based on scouting results for both injurious and beneficial mite species. The "TO DO" list for each pest identifies what needs to be accomplished in terms of registrations, research, and education in order for the transition away from OP use to be a success.

Attachments:

Table 1: A revised (from Penn State data) efficacy table for the pests and pest management tools for the Mid-Atlantic/Appalachian/Southeastern apple production region.
Table 2: Key to pest abbreviations.
Table 3: Revised (from Penn State) ratings for the effects of the miticides/insecticides on key beneficial mite and aphid predators.
Table 4: A glossary of active ingredient product names.
Table 5: Short descriptions of the main insect species.

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Prebloom

1. Rosy Apple Aphid (RAA): Most orchards receive a prebloom insecticide application for control of this pest.
OP insecticides currently used:

Chlorpyrifos
Diazinon
Dimethoate
Methidathion

Notes:
- OPs will also control San Jose Scale (SJS) if present at time of RAA sprays.
- Localized RAA resistance exists to chlorpyrifos.

Non-OP insecticides currently used:

Esfenvalerate
Permethrin
Endosulfan

Notes:

- Pyrethroids are effective in controlling RAA and can be used if applied before European red mite (ERM) eggs hatch and/or before mite predators are in the trees. Use may upset mite management programs by destroying predator mites/insects but less deleterious at this time than later pyrethroid applications. Will also control climbing cutworms, adult spotted tentiform leafminer, and tarnished plant bug.
- Localized RAA resistance exists to esfenvalerate and permethrin,
- Pyrethroids are not effective against scale so a tank mix of pyrethroids plus oil is needed to control RAA and SJS.
- One spray of endosulfan plus a spray of oil is needed to control both RAA and SJS .

Non-chemical alternatives used:

None identified

Pipeline pest management tools:

Triazamate: selective for aphids, efficacy equivalent to diazinon
Pirimicarb: selective for aphids, efficacy equivalent to diazinon
Thiomethoxam:
Pyriproxyfen: for SJS, less effective than OPs

"TO DO" List for RAA:

Regulatory:
- register some or all of the pipeline chemicals. To help prevent resistance development the availability of 2-3 compounds is preferred.

Research:
- fund and conduct research to better identify biology and life cycle of the RAA

Education:
- explain monitoring techniques, use of economic thresholds, and proper timing of spray applications

2. Oblique Banded Leafroller (OBLR): typically controlled during post-bloom but occasionally appears and needs controlling during pre-bloom period; a sporadic pest in this region, need to control occurs on an individual orchard basis. (See OBLR under Post-bloom time period for specific management tools.)

"To Do" List for OBLR:

Regulatory:
- registration of pyriproxyfen and methoxyfenozide

Research:
- evaluate pre-bloom treatments
- evaluation of pyriproxyfen and methoxyfenozide as management tools
- economic threshold studies

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Petal Fall - a critical time for OP use.

The use of an OP insecticide at petal fall is recommended because of broad spectrum control of several apple pests: plum curculio, oriental fruit moth, European apple sawfly, redbanded leafrollers, green fruitworm and plant bugs. Azinphos-methyl and phosmet are the most effective materials for use in controlling this set of pests. If OPs were not available there would be severe mite problems as current mite management programs would be disrupted by the use of esfenvalerate.

1. Plum Curculio (PC): a major driver of OP use

OP insecticides currently used:

Azinphos-methyl
Phosmet
Chlorpyrifos: use may result in weather induced russetting

Notes:

- for plum curculio control there are no alternatives, either currently-registered or in the pipeline, that provide as effective control as phosmet or azinphos-methyl.

Non-OP insecticides currently used:

Esfenvalerate
Permethrin
Kaolin: testing shows less effective than azinphos methyl; not registered for use on East coast

Notes:

- pyrethroids are the next most effective alternatives for plum curculio - however, use is unacceptable and discouraged as it will upset mite management programs for the entire season by destroying predator mite populations

Non-chemical alternatives:

None identified

Pipeline pest management tools:

Thiomethoxam
Indoxacarb

Notes:

- testing shows these to be less effective than azinphos-methyl

"To Do" list for PC:

Regulatory:
- register one or more of the pipeline chemistries

Research:
- develop population monitoring tools for predicting spray timing
- validate degree day model for predicting appearance of the pest
- identify pheromones for possible mating disruption programs
- research on fipronil and screening for new compounds is a priority
- PHI and residue research for use in mitigation strategies

Education:
- new tools and pest management practices are needed before education can occur

2. Oriental Fruit Moth (OFM): First generation OFM is generally controlled with the petal fall spray for PC.

3. European Apple Sawfly (EAS) : A new pest to this region. Populations are moving southerly. Timing of control is important because even though the pest occurs during bloom, damage is not seen until after petal fall. PC sprays during petal fall control this pest as well. Potential exists for developing into a serious pest in this region.

OP insecticides currently used:

Azinphos-methyl: very effective

Phosmet: very effective

Chlorpyrifos: use may result in weather induced russetting

Non-OP insecticides currently used:

Esfenvalerate and permethrin: disrupt mite management programs for the entire season by destroying predators

Pipeline pest management tools:

Nothing identified in the pipeline

Indoxacarb: researchers only speculate as to its effectiveness

"TO DO" list for EAS:

Regulatory:
- need tools in the pipeline first

Research:
- distribution studies needed due to it's expanding range
- pest biology and behavior need to be studied
- monitoring techniques need to be developed and evaluated
- screening for potential management tools
- survey for natural enemies

Education:
- pest biology and behavior
- use of monitoring tools once developed

4. Redbanded Leafroller (RBL): First generation adults emerge from wooded areas adjacent to the orchards at green-tip to half inch-green stage; eggs hatch at petal fall, larvae need to be controlled

OP insecticides currently used:

Azinphos-methyl

Phosmet

Chlorpyrifos

Non-OP insecticides currently used:

Tebufenozide

Bt

Notes:

- this pest is effectively managed with the above non-OP chemistries

“TO DO” List for RBL:
Regulatory:

Research:
- development and screening of new materials

5. Green Fruitworm (GFW):
OP insecticides currently used:
- Azinphos-methyl
- Phosmet
- Chlorpyrifos

Non-OP insecticides currently used:

Tebufenozide
Bt

Notes:
- this pest is effectively managed with the above non-op chemistries

Pipeline pest management tools:

Fenoxycarb
Methoxyfenozide

“TO DO” List for GFW:
Regulatory:
- Possible registration of methoxyfenozide

Research:
- development and screening of new materials

6. Plant Bugs (Tarnished, Lygus, and Red):
OP insecticides currently used:

Azinphos-methyl
Chlorpyrifos
Dimethoate

Non-OP insecticides currently used:

Esfenvalerate
Permethrin
Endosulfan
Formetanate HCL

Notes:
- use of pyrethroids disrupts mite management programs for the entire season by killing off predators

Non-chemical alternatives used:

Elimination of broadleaf weeds on the orchard floor will help minimize plant bug damage

Pipeline pest management tools:

Indoxacarb: effectiveness is questionable, speculation as to usefulness

“TO DO LIST” for Plant Bugs:
Research:

- development and screening of new materials
- possible pheromone work for monitoring

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Early Cover Sprays (10-30 days post bloom): an important time for OP use.

1. Codling Moth (CM): major driver of OP use; the main target for the first cover spray; may require 1-2 sprays

OP insecticides currently used:

Azinphos-methyl
Chlorpyrifos: short residual, good control if populations are low
Methyl parathion: less expensive but has bee problems and worker safety issues
Phosmet

Notes:

- all the above OPs are rated from good to excellent in controlling CM

Non-OP insecticides currently used:

Carbaryl (carbamate): high rates needed to be effective
Methomyl (carbamate): high rates needed to be effective, short residual
Esfenvalerate
Tebufenozide: effective
Summer oils: compatibility problems when tank mixed with fungicides
Kaolin: some researchers have rated this highly effective, others have not

Notes:

- use of these carbamate and pyrethroid chemistries leads to pest mite flare ups that may last one or more seasons due to the disruption of predator populations
- future use of carbamates is as uncertain as that of the OPs due to similar modes of action
- resistance to tebufenozide has been reported in Europe

Non-chemical alternatives used:

Pheromone mating disruption
Pheromone trapping to determine the need and timing of control actions

Notes:

- costly, works better in larger orchards
- less effective in this region than in the Northwest due to orchard configuration (long and slender) and the influx of high numbers of CM from border areas (abandoned orchards and wild native hosts)

Pipeline pest management tools:

Indoxacarb: highly effective
Fenoxycarb: highly effective
Methoxyfenozide: highly effective

Notes:

- resistance to fenoxycarb and methoxyfenozide and cross resistance to the pyrethroids has been reported in Europe

"TO DO LIST" for CM:

Regulatory:
- register the pipeline chemistries
Research:
- screening of new insecticides
- mating disruption including feasibility, economics, application methods (puffer-type systems), multiple-pest pheromone release systems
- cross resistance issues between new products and the OPs
- contribution to pest populations from non-orchard hosts
- efficacy of a granulosis virus
Education:
- teach growers new methods, timing, and techniques as they become available

2. San Jose Scale (SJS): a driver of OP use; the crawler stage is the target; not a widespread problem but could increase if OPs not available; can result in potential tree loss if not controlled

OP insecticides currently used:

Methyl parathion
Chlorpyrifos
Phosmet
Azinphos-methyl

Notes:

- methyl parathion and chlorpyrifos are equally efficacious and both work better than phosmet or azinphos-methyl.

Non-OP insecticides used:

Imidacloprid: efficacy research is needed
Summer oils

Non-chemical alternatives used:

Black sticky tape is used for monitoring SJS crawlers, determines control needs and timing

Pipeline pest management tools:

Pyriproxyfen: slightly less effective than OPs
Thiomethoxam

"TO DO" List for SJS:

Regulatory:
- expedited registration of pyriproxyfen and thiomethoxam
Research:
- screening and development of new compounds
- validation of the Degree-Day models in the East
- parasite research – potential may exist
- integrate biological control and pesticide timing
Education:

- train and educate growers in use of new tools as they are developed and become available

3. Plum Curculio (PC: second application) : workshop participants identified that the first cover spray may be driven by the need to control PC (see discussion above for management options).

4.Comstock Mealybug (CMB): this pest is showing up in experiments where OPs have been eliminated from the system; the CMB is currently being controlled with sprays targeted at codling moth.
OP insecticides currently used:
Chlorpyrifos
Methyl parathion
Non-OP insecticides currently used:
Imidacloprid
Non-chemical alternatives used:
None identified
Pipeline pest management tools:
Acetamiprid
Thiomethoxam
"TO DO" list for the CMB: especially in North Carolina:
Regulatory:
- expedited registration of pipeline chemistries
Research:
- efficacy studies on pipeline chemistries, there is some indication that they may be efficacious against CMB
- biology and behavioral studies to identify weak links
- screening /development of new management tools
- monitoring techniques and economic thresholds need to be developed
Education:
- as new tools are developed and /or registered, educate growers in use

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Middle Cover Sprays (30-60 days post-bloom)

1. Woolly Apple Aphid (WAA): WAA often becomes a pest as a result of carbamate (methomyl) or pyrethroid use or the year after cicada control is applied.
OP insecticides currently used:
Methyl parathion
Malathion
Chlorpyrifos
Non-OP insecticides currently used:
Endosulfan: efficacy is questionable
Non-chemical alternatives used:
Rootstock resistance
Parasites
Pipeline pest management tools:
Triazamate
Pirimicarb

Acetamiprid
Thiomethoxam

“TO DO” list for WAA:

Regulatory:
- expedited registration of pipeline materials

Research:
- more work is needed to identify beneficials and their effectiveness
- efficacy work on the pipeline materials
- economic threshold work and monitoring programs

Education:
- educate and train growers as to use of new management tools as they are developed

2. Leafrollers (Oblique Banded Leafroller (OBLR) and Tufted Apple Bud Moth (TABM): in the past OBLR and TABM have been drivers of OP use as part of the second cover spray. OBLR resistance to OPs and TABM resistance to the OPs and carbamates is changing this.

OP insecticides currently used:

Chlorpyrifos: still effective against the OBLR
Methyl parathion and azinphos-methyl still used for TABM where resistance does not occur

Non-OP insecticides currently used:

Spinosad
Bt
Methomyl
Tebufenozide
Esfenvalerate: use leads to mite flare ups

Non-chemical alternatives used:

None identified

Pipeline pest management tools:

Indoxacarb
Methoxyfenozide
Mating disruption
Emamectin benzoate

“TO DO” list for leafrollers:

Regulatory:
- expedited registration of pipeline chemistries

Research:
- mating disruption for multiple pest species and delivery systems
- economics of mating disruption techniques
- biocontrol studies
- resistance and cross resistance studies for pipeline chemistries and the OPs
- genetic engineering (Bt insertion into apple tree)
- develop good economic threshold levels using traps as predictors for spraying

Education:
- as new tools become registered/available

3. Japanese Beetle (JAB):
OP insecticides currently used:
Methyl parathion
Phosmet
Notes:
- OPs are used when beetle populations are low to moderate

Non-OP insecticides currently used:
Carbaryl
Esfenvalerate
Kaolin
Notes:
- Carbaryl: used when beetle populations are high; may cause mite flare ups due to toxicity to beneficial mites and insects; cheaper than the other alternatives

Non-chemical alternatives used:
None identified

Pipeline pest management tools:
None identified

“TO DO” list for JB:
Regulatory:
- nothing in the pipeline to register

Research:
- development and screening of new materials
- use of feeding attractants and baits
- use of repellents – some natural plant substances have been identified as possibilities
- research on the use of kaolin

Education:
- programs will be needed as new tools become available

4. Flatheaded Borers, Roundheaded Borers, Dogwood Borer (DB) and American Plum Borer (APB): major drivers of OP use; pesticide applications are made to the tree trunk as pests emerge from soil, climb up the trunk and oviposit eggs.
OP insecticides currently used:
Chlorpyrifos
Methyl parathion

Non-OP insecticides currently used:
Endosulfan: less effective, more costly
Esfenvalerate

Non-chemical alternatives used:
Mounding soil to cover burrknots below graft union

Pipeline pest management tools:
Mating disruption pheromone

“TO DO” list for borers:
Regulatory:

- provide incentives for research of new products
Research:
- research rootstock susceptibility
- cultural practices, orchard floor management, role of tree guards
- mating disruption with pheromones
- screening/developing new products
- white paint/insecticide application methods
Education:
- educate/train growers as new tools become available

5. San Jose Scale (SJS): crawler stage may overlap into this time period; see discussion above for management practices

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Mid-to-Late Cover Sprays (60-90 days post-bloom): this is the second most important time for OP use

1. Apple Maggot (AM): the most important driver of OP use during this time period; may require 2-3 applications to control; oriental fruit moth may be controlled at the same time as the AM during the 60-75 day post-bloom period, and second generation CM may be controlled at the same time as the AM during the 75-90 day post-bloom period.

OP insecticides currently used:
Azinphos-methyl
Phosmet
Chlorpyrifos: short residual
Methyl parathion
Notes:
- azinphos-methyl and phosmet are very effective
Non-OP insecticides currently used:
Carbaryl: provides less control
Esfenvalerate: destroys predators of mites, causing mite flare-up
Spinosad: costly, requires weekly applications
Kaolin: not registered on East coast
Non-chemical alternatives used:
Mass trapping: costly, not as effective as above control measures
Pipeline pest management tools:
Attract and Kill: a feeding stimulant plus imidacloprid mixed in paint and applied to wooden spheres
Indoxacarb: efficacy is questionable
"TO DO" list for AM:
Regulatory:

- register pipeline products
Research:
- screening/development of new compounds
- on new control strategies: attract and kill methods, red spheres
- sterile male techniques: are very expensive
- breeding programs for resistant varieties
Education:
- educate/train growers as new techniques become available

2. Oriental Fruit Moth (OFM): a driver of OP use; this pest may occur along with the AM during the 60-75 day post-bloom period, and if timing is optimal the same application will control both pests

OP insecticides currently used:

Azinphos-methyl
Phosmet
Chlorpyrifos
Methyl parathion

Non-OP insecticides currently used:

Esfenvalerate: use results in mite problems
Carbaryl: tough on beneficials

Non-chemical alternatives used:

Mating disruption: prophylactic, does not eliminate a spray; cost has come down recently ($40 per acre); very pest specific whereas one spray with OPs controls many pests

Pipeline pest management tools:

Indoxacarb: efficacy is questionable
Methoxyfenozide: efficacy is questionable

"TO DO" list for OFM:

Regulatory:
- expedited registration of pipeline chemicals
Research:
- screen and perfect mating disruption materials
- validate egg hatch model for predicting spray timing
- population dynamics
- economics of controlling multiple pests with single applications, especially when dealing with 0 tolerance pests
- residue and post-harvest interval studies
- resistance studies involving cross resistance between OPs and newer chemistries
Education:
- educate/train growers as new technologies become available

3.Codling Moth (CM) Second generation: a major driver of OP use; the second application for AM may control the second generation CM if they occur at the same time; if timing of the two pests does not coincide then additional applications will be needed to control one or the other; see CM information from the Early Cover Sprays section for details.

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Late Cover Sprays (90 days post-bloom through harvest):

Those pests with multiple generations per year will reappear during this time frame (see earlier discussions regarding the specific management options for each pest):

Codling Moth
San Jose Scale
Leafrollers
Oriental Fruit Moth
Apple Maggot
Dogwood Borer

Workshop participants stated that if all has been done correctly up to this point, there are usually no problems in the late season. The group was concerned that the use of pest selective sprays rather than broad spectrum ones early in the season may result in more pest problems closer to harvest. The group stated that timing becomes critical when compounds with a narrow pest range and a small window of opportunity are used. Participants were concerned that the lack of organophosphate use in earlier sprays might lead to new pest problems at this later stage, and that early season use of OPs may allow alternatives to work better in the late season.

"Early season control writes the late season story"

Table 1. A revised efficacy table for the pests and pest management tools for the Mid-Atlantic/Appalachian/Southeastern apple production region.

	Pest[c]																								
Pesticide[d]	AM	ARM	CM	EAS	ERM	GA	GFW	LAW	OBL	OFM	PB	PC	PLH	RAA	RBL	RLH	SJS	STLM	TABM	TSM	WAA	WALH	BOR	CIC	MLY	JAB
Abamectin	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	3				
Clofentezine	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—				
Esfenvalerate	2	—	1	2	—	2	2	1	1	1	1	2	2	1	1	2	4	1	1	—	4	2	2	1		2
azinphos-methyl	1	—	1	1	—	4	2	1	2	1	3	1	3	3	2	3	3	4	3	—	4	3		4		3
B. thuringiensis	4	—	3	—	—	4	3	3	2	3	4	4	4	4	1	4	4	4	2	—	—	4				-
carbaryl	2	—	2	3	—	4	3	2	3	2	—	2	1	3	3	1	3	3	4	—	4	1		2		1
Formetanate HCL	—	3	—	—	2	—	—	—	—	—	2	—	1	—	—	1	—	2	—	2	—	1		-		-
chlorpryrifos 4E	—	—	—	—	—	4	2	—	—	—	3	—	—	2	2	—	1	—	—	—	—	—				
diazinon	2	2	2	2	—	3	2	2	3	2	2	2	2	1	2	2	2	3	2	—	4	2				
dimethoate	3	—	3	4	—	1	4	3	4	3	2	4	2	2	4	2	2	3	4	—	2	2				
dormant oil	—	—	—	—	1	3	—	—	—	—	—	—	—	3	—	—	1	—	—	—	—	—				
endosulfan	3	2	3	—	—	4	4	4	3	1	3	2	3	4	2	3	2	4	—	3	2	2				
Phosmet	1	—	1	1	—	4	3	1	2	1	3	1	4	3	2	4	3	4	3	—	4	4		4		1.5
Dicofol	—	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—				
Methomyl	3	—	2	3	—	3	2	2	1	2	2	3	2	3	1	2	3	1	1	—	4	2		2		3
Chlorpyrifos 50WP	2	—	2	2	3	2	2	2	2	2	2	2	4	2	2	4	2	4	2	—	3	4	1	4	1	3
Soap	—	—	4	—	3	4	4	—	4	4	—	4	2	4	4	2	3	4	4	3	—	2				
Permethrin	—	—	—	3	—	2	2	—	1	1	1	2	—	1	1	2	4	1	—	—	4	2				
Methyl parathion	2	—	1	3	—	4	2	1	2	1	2	2	4	4	1	4	1	4	2	—	1	4	3	4	2	1.5
Imidacloprid	—	—	—	—	—	1	—	—	—	—	—	—	1	1	—	1	—	2	—	—	__	1				
Pyridaben	—	1	—	—	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	2				
Hexythiazox	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—				
Oil	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—				
Methidathion	—	—	—	—	—	3	1	—	—	—	3	—	—	1	1	—	1	—	—	—	—	—				
Fenbutatin oxide	—	2	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—				
Oxamyl	—	2	—	—	2	3	—	—	—	—	2	—	2	2	—	2	—	2	—	2	4	2		2		
Spinosad	2		3			_	_	_	3	2	3	_	_	_	_	2	_	_	1	1	_	_	_			
Tebufenozide	_	_	1.5	_	_	_	2	3	2	4	_	_	_	_	1	_	_	3	1	_	_	_				
Indoxacarb	?	_	1.5	?	_	_	2	2	2	2		?	?	_		1	_	?	_	1	_	_	_			
Fenoxycarb	_	_	1	_	_	_	1	?	1	?	_	_	_	_	1	_	_	1	_	_	_	_				
Kaolin	?	?	2.5	_	2.5	2	?	?	?	?	?	?	2	?	?	?	_	3	3	2	_	1				
Mating Disruption	_	_	2	_	_	_	_	3	3	2	_	_	_	_	_	_	_	_	2	_	_	_		?		
Emamectin	_	_	3	_	_	_	2	3	2	3	_	_	_	_	_	_	_	2	1	_	_	_				
Methoxyfenozide	_	_	1	_	_	_	1	?	1	2	_	_	_	_	1	_	_	2	1	_	_	_				
Pyriproxyfen	_	_	1	_	_	_	?	?	?	?	_	_	_	_	?	_	2	1	_	_	_	_				
Pirimicarb	_	_	_	_	_	1	_	_	_	_	_	_	_	1	_	_	_	_	_	_	?	_				
Triazamate	_	_	_	_	_	1	_	_	_	_	_	_	_	1	_	_	_	_	_	_	1	_				
Thiomethoxam	_	_	_	_	_	3	_	_	_	_	?	?	?	?	?	?	_	_	_	_	?	?				

[a] *Pest control rating system when used at recommended rates: 1 = excellent, 2 = good, 3 = fair, 4 = poor, — = not rated for this insect or mite. Ratings are based on moderate insect or mite pressure. Heavy infestation may require either higher dosage, shorter intervals, or both.*

[b] *Fruit finish on yellow varieties when used as directed excellent for all products except the following: good for dimethoate EC, diazinon, and Chlorpyrifos 50WP, and poor for M-Pede.*

[c] *See Table.*

Table 2. Key to pest abbreviations.

CODE	PEST
BOR:	DOGWOOD BORER
CIC:	PERIODICAL CICADA
MLY:	COMSTOCK MEALYBUG
JAB:	JAPANESE BEETLE
AM:	APPLE MAGGOT
ARM:	APPLE RUST MITE
CM:	CODLING MOTH
EAS:	EUROPEAN APPLE SAWFLY
ERM:	EUROPEAN RED MITE
GA:	GREEN APPLE APHID
GFW:	GREEN FRUITWORM
LAW:	LESSER APPLE WORM
OBL:	OBLIQUEBANDED LEAFROLLER
OFM:	ORIENTAL FRUIT MOTH
PB:	PLANT BUG
PC:	PLUM CURCULIO
PLH:	POTATO LEAFHOPPER
RAA:	ROSY APPLE APHID
RBL:	RED BANDED LEAFROLLER
RLH:	ROSE LEAFHOPPER
SJS:	SAN JOSE SCALE
STLM:	SPOTTED TENTIFORM LEAFMINER
TABM:	TUFTED APPLE BUD MOTH
TSM:	TWOSPOTTED SPIDER MITE
WAA:	WOOLY APPLE APHID
WALH:	WHITE APPLE LEAFHOPPER

Table 3. Toxicity of pesticides to mite and aphid predators

Mite Predators

Material	Stethorus adults	Stethorus larvae	Amblyseius fallacis	Zetzellia mali	Aphid-oletes	General aphid predators
Insecticides/miticides						
Abamectin	++	++	++	++	-	-
Clofentezine	0	0	+	+	+	+
Esfenvalerate	+++	+++	+++	++	++	+++
azinphosmethyl	+	+	+	+	+++	++
Bt	0	0	0	0	-	0
Carbaryl	+++	+++	++	++	+++	++
Formetanate HCL	+	++	+++	++	-	++
Chlorpyrifos	+	+	++	++	-	++
Dimethoate	+	+	+++	-	+++	++
Diazinon	+	+	-	-	+++	++
Endosulfan	++	++	+	-	++	++
Phosmet	+	+	+	+	0	+
Dicofol	+	+	++	+	+	+
Methomyl	++	++	+++	++	+++	+++
Malathion	-	-	-	-	-	-
Soap	++	++	-	-	-	++
Methyl parathion	+	+	+	+	+	++
Permethrin	+++	+++	+++	++	+	++
Imidacloprid	++	++	+	+	-	++
Pyridaben	++	++	-	-	-	++
Hexythiazox	0	0	+	+	-	+
Oil	+	+	++	++	-	++
Fenbutatin Oxide	+	+	+	+++	+	+
Oxamyl	++	++	+++	+++	++	++
Spinosad	0	0	0	0	0	0
Tebufenozide	0	0	0	0	0	0
Methoxyfenozide	0	0	0	0	0	0
Indoxacarb	++	++	+	+	++	++
Triazamate	+	+	+	+	+	+
Acetamiprid	++	++	+	+	++	++
Fenoxycarb	+++	+++	0	0	+	++
Pyriproxyfen	++	++	0	0	+	++
Emamectin	+	+	0	0	?	?
Kaolin	+++	+++	?	?	?	++
Pirimicarb	+	+	+	+	+	+

+ = slightly toxic, ++ = moderately toxic, +++ = highly toxic, - = no data available , 0 = nontoxic

b General aphid predators include coccinellids, lacewings, syrphid fly larvae, minute pirate bugs, and mullein bugs.

TABLE 4
Insecticides/Miticides for Apples

Active Ingredient	Trade Name
Abamectin	Agri-Mek
Clofentezine	Apollo
Esfenvalerate	Asana
Azinphos Methyl	Guthion
Carbaryl	Sevin
Formetanate HCL	Carzol
Chlorpyrifos	Lorsban
Endosulfan	Thiodan
Phosmet	Imidan
Dicofol	Kelthane
Methomyl	Lannate
Soap	M-Pede
Methyl Parathion	Penncap-M
Permethrin	Ambush, Pounce
Imidacloprid	Provado
Pyridaben	Pyramite
Hexythiazox	Savey
Fenbutatin-oxide	Vendex
Oxamyl	Vydate

Experimental Compounds

Active Ingredient	Trade Name	Company
Spinosad	SpinTor	Dow Agrosciences
Tebufenozide	Confirm	Rohm & Haas
Indoxacarb	Avaunt	Dupont
Pirimicarb	Pirimor	Zeneca
Triazamate	Aphistar	Rohm & Haas
Thiomethoxam	Actara	Novartis
Methoxyfenozide	Intrepid	Rohm & Haas
Pyriproxyfen	Knack/Esteem	Valent
Fenoxycarb	Comply	Novartis
Emamectin benzoate	Proclaim	Novartis
Kaolin	Surround	Engelhart
Acetamiprid		Rhone-Poulenc Sedagri

TABLE 5
Description of Key Insect Pests

Dogwood Borers feed beneath the bark and may girdle the tree. Persistent infestations over several years can reduce tree vigor and yields.

Japanese Beetle adults feed on leaves, causing foliage to be skeletonized.

Comstock Mealy Bug infests the calyx end of fruit, and their honeydew secretions serve as a substate for growth of sooty molds.

Apple Maggot females deposit eggs directly into apples. Larvae hatch and tunnel throughout the apple.

Rosy Apple Aphids feed on leaves. Injured leaves become curled and twisted. Foliage feeding also results in stunted and malformed fruit.

European Apply Sawfly females lay eggs on apples. The larvae mine just under the skin. The tunneling of the larvae creates a large russeted scar.

Plum Curculio adults damage the apple in two ways: feeding injury and egg laying injury. Feeding punctures consist of small round holes one-eighth inch into the fruit. Egg punctures are distinguished by a characteristic crescent shaped cut that surrounds the sunken egg.

San Jose Scale crawlers insert their beaks through the bark to feed on tree sap. Heavy infestations contribute to overall decline in tree vigor, growth and productivity and may result in small deformed fruit. The fruit and leaves may also become infested.

Codling Moth/Oriental fruit moth eggs are laid primarily on leaves near fruit. Hatched larvae burrow into fruit and either feed briefly on the flesh just below the surface or burrow directly to the center of the apple, where they feed on the seeds. OFM also causes shoot injury.

Leafrollers (TABM, OBLR, RBL) larvae feed on leaves and on the fruit surface. This group of insects is responsible for most of the downgrading of fruit in this region.

Green fruitworm larvae feed on leaves and on the surface of fruit.

Plant Bugs adult feeding results in dimples in the fruit.

Woolly apple aphids produce galls on roots and branches of trees. Honeydew deposits from above ground feeding can result in sooty mold on the fruit.